ADDRESS

Delivered by the President, Edwin Dunkin, F.R.S., on presenting the Gold Medal of the Society to Professor Edward C. Pickering, For. Assoc. R.A.S., and Professor Charles Pritchard, D.D., F.R.S.

GENTLEMEN,

The Council have awarded the Gold Medal conjointly to Prof. Edward C. Pickering, Director of the Observatory of Harvard College, U.S., and the Rev. Charles Pritchard, D.D., Savilian Professor of Astronomy in the University of Oxford, for their "Photometric Researches." It now devolves upon me, as your President, to explain generally the grounds upon which this award is based.

You may remember that in June, 1871, a new bye-law was enacted by the Society, on the recommendation of the Council, to authorise the award of a joint Medal when it appears expedient to recognise the independent researches of two or more persons who have been working independently on the same subject, and who at about the same time have announced publicly the results of their separate labours. In past years much inconvenience has been experienced for want of such a power on the part of the Council, though on one occasion in 1867 means were found to justify the award of a joint Medal. But in this case the recipients were co-workers, and the Fellows, with enthusiasm, condoned that somewhat irregular act of the Council, which apparently was a departure from a course which the bye-laws had prescribed. On inspecting the new bye-law, enacted in 1871, it will be perceived that the Council are now authorised to receive the nomination of two or more persons as joint recipients of the Medal, provided that the nominees are the simultaneous, but independent, authors of any treatise, work, research, or discovery; and the bye-law goes on to say that "should the Medal be ultimately awarded to such joint authors, workers, or discoverers, an impression of the Medal shall be provided for and given to each of such joint recipients." The Council have therefore great pleasure in carrying out, for the first time, the terms of this new bye-law, by their award recognising the important and interesting stellar researches independently carried on by Profs. Pritchard and Pickering, as a comparatively

new subject of physical inquiry, combining new principles and apparatus in the investigation.

Since the appointment of Prof. Pickering to the superintendence of the Observatory of Harvard College he has devoted much time and attention to the subject of the comparative lustre of the stars, the results of which have from time to time been communicated to astronomers. The magnitude of his work on the photometry of the stars was not, however, realised till the appearance in 1884 of the first part of Vol. XIV. of the *Annals of the Astronomical Observatory of Harvard College*, which includes the results of his photometric examination of all stars of the sixth magnitude to 30° south declination. This great work contains chapters giving a detailed description, with diagrams, of the meridian photometer used in the investigation; a summary of the whole series of observations, including a discussion of the estimated magnitudes of *Polaris*, the star to which all other stars were referred; notes on the atmospheric absorption of light; on eye-estimations of the brightness of the stars, visible to the unaided eye, for comparison with the corresponding photometric determinations; and a general catalogue giving in tabular form the main results of the entire investigation. The number of stars included in the catalogue is 4,260, representing 700 series of observations, and 94,476 separate comparisons made between October 25, 1879, and September 17, 1882. The list contains all the stars not fainter than the sixth magnitude between the North Pole and 30° south declination, or as low as stars can be conveniently observed for this purpose in latitude 42° N. The stars were selected from several standard catalogues, in which the magnitude is given as, at least, the sixth. They have all been observed near the meridian, where they have the greatest altitude, thus facilitating the computation of the correction for atmospheric absorption. A second part of the work appeared in 1885, consisting mainly of a detailed discussion and comparison of all the original star-magnitudes found in various original catalogues, from Ptolemy and Al Sûfi to modern times, and it is a discussion of some magnitude, exhibiting in its compilation the results of great zeal and research. In addition to this comparison, the second part includes separate chapters on discordant observations, suspected variables, the distribution of stars, and other subjects.

The instrument devised by Prof. Pickering, and which appears to have been perfectly successful, has been named by him the Meridian-Photometer. It consists of a horizontal telescope pointing to the west, having two similar object-glasses of about four centimetres aperture and 80 centimetres focal length. Right-angled prisms are placed in front of the object-glasses, through which the images of the stars to be measured and the comparison star, *Polaris*, are reflected. The prism through which *Polaris* is reflected may be turned by rods around two axes, one perpendicular to the axis of the telescope, the

other coinciding with it. By these two motions *Polaris* may always be brought into any part of the field of view. The prism which reflects the star to be measured may also be turned around the axis of the telescope, and it carries a graduated circle, divided into degrees, the index of which is so adjusted as to give the declination of the star reflected. This prism can also be inclined by means of a screw so as to vary the collimation if required. A further technical detail of the photometer I give strictly in Prof. Pickering's own words: "The use of two objectives might be expected to produce two separate emergent pencils. Errors would then be caused by a slight movement of the eye of the observer, a portion of one pencil being sometimes cut off by the edge of the pupil. Moreover, we cannot be sure that different portions of the eye are equally transparent. Different pencils would likewise pass through different portions of the eyepiece, and would be unequally reduced by the dust upon its surfaces. To avoid these various sources of error, the double-image prism is placed near the focus of the objectives. This prism is made of Iceland spar compensated by glass. Each pencil is thus divided into two. The northern of the two pencils from the southern objective is made to coincide with the southern of the two northern pencils. This is effected by varying the angles of the spar and glass prism. As the prisms are cemented together, the interval between the two images may be varied by grinding the face of the spar, while a change in the glass face moves both images together. Two or three trials sufficed to make the two central pencils coincide, and pass nearly through the centre of the eyepiece. In front of the latter is placed a Nicol. An eye-stop has an aperture of such a size that it will admit the central pencils and cut off the two outside pencils. By placing this stop a little excentrically, the slight deviation of the pencils in traversing the Nicol was corrected. The pencils forming the images to be compared are therefore coincident, and are formed by precisely similar object-glasses. A graduated circle, divided into degrees, is attached to the eyepiece and Nicol, and on turning it through any angle from the point where one image disappears, the light of that image will evidently be proportional to the square of the sine of the angle. An index serves to measure this angle in degrees and tenths." Some difficulty was at first experienced from the imperfection of the annealing of the reflecting prisms, but this was overcome by a method of local correction, by which a better definition of the images was obtained. Great credit is due to Prof. Pickering for devising the meridian photometer, which in his hands has been so successful; for though it may be considered in some respects an adaptation of previously existing photometers, there can be no question as to the fact that he has introduced so many important modifications that makes it, in reality, a new and original instrument.

Prof. Pickering had the aid of a large staff of assistants dur-

ing the three years occupied by these observations. The following is a brief sketch of the daily routine of work. To observe with the meridian-photometer two persons are required. The image of *Polaris* is first brought by the observer into the middle of the field of view, by the two handles moving the northern prism. An assistant, who records the observation, then, by means of the declination-circle, directs the southern prism to the star to be measured, which is brought into the middle of the field by the collimating screw. "The observer places the image of the Pole-star near that of the star to be measured and makes a setting by turning the Nicol until the images appear to be equal. He then notifies the recorder to enter the reading, which is done to tenths of a degree. On being notified by the recorder that the reading has been made, he turns the Nicol so that the image of the Pole-star just disappears and then regains a brightness equal to that of the other star. This second setting is recorded while the observer reverses the images by moving the northern prism. Two more settings are then made in the same way as before." It was usual to call the work of each observer on a single evening by a distinguishing number or series. Each series was limited to about an hour, the observations being continuous, one star being brought into the field as soon as the preceding star had been measured. By limiting a series to an hour, any injurious effect arising from the fatigue of the eye was diminished.

The success of the meridian-photometer in the investigation before us induced Prof. Pickering to construct a larger instrument of improved form, with which he has been enabled to observe the photometric magnitudes of Neptune, some of the minor planets, and objects generally not fainter than the tenth magnitude. The object-glasses are about four inches aperture and sixty inches focal length, and the instrument differs from the smaller one in many of the details. In his report of the work of the Harvard Observatory from 1877 to 1882, Prof. Pickering states that he intends to employ this larger photometer "in the revision of the stars of the northern heavens where the zones of the various observatories overlap by a small amount. Over eight thousand stars are contained in these overlapping portions. The light of all these stars is to be determined with it, and the estimates of light of the various observers in the entire work of revision may thus be reduced to a single standard. Besides this work, the standard stars of the *Uranometria Argentina*, the comparison stars for variables, and other objects of interest will be measured."

In a more recent report, Prof. Pickering states that the observations with the new meridian-photometer have been regularly continued, and in some measure extended. During the year 1885 more than two hundred series of observations were made, representing upwards of fifty thousand separate settings, or nearly double the number made in the preceding

year. The accordance of the results continues satisfactory, the average deviation of the separate measures of the standard circumpolar stars being about ·12 of a magnitude. In order to increase the regularity of distribution of the stars observed, other zones of 20′ in width have been added to those previously selected for observation, so that the entire series now includes zones at intervals of five degrees from the equator to the pole.

In some instances Prof. Pickering has adopted the wedge-photometer for the determination of the photometric magnitudes of the fainter class of objects, as in the revision of the magnitudes in the *Durchmusterung*; faint stars selected as standards of magnitude in twenty-four regions following bright stars; and also stars which have been used as standards of comparison for variable stars. When these comparison stars are of sufficient brightness, they have been usually measured by the meridian photometer, and their magnitudes, thus determined, serve as a basis for the measurement of the fainter stars by the wedge-photometer. "Two observations of each star not determined by the meridian-photometer, and of a sufficient number of the others, are made with the wedge on each evening when the region occupied by the comparison stars of any particular variable is observed. Two complete observations of this kind, made on different evenings, are regarded as sufficient; but when moonlight or other causes render the work of either evening imperfect, it is repeated on a third evening." Prof. Pickering does not consider that the wedge-photometer employed at the Harvard Observatory is capable of the great degree of precision claimed for the Oxford photometer, and in order to ascertain whether this difference is due to the form of the instrument, he has requested Prof. Pritchard to superintend the construction of a wedge-photometer, upon the same plan as that at Oxford, for use at the Harvard Observatory. This instrument is now completed by Mr. Hilger, and is, or soon will be, in the hands of Prof. Pickering.

For the determination of the law of atmospheric absorption, Prof. Pickering selected 100 of the brighter stars, none being fainter than the sixth magnitude, between 60° and 75° north declination, some of which were observed on each evening at their upper and others at their lower culmination. A table is given showing the observed magnitude of each star, from which the adopted coefficient of absorption has been determined to be ·250. The diminution of brightness at the lower culmination indicates to what extent the magnitude of the star is affected by the atmosphere.

It is impossible, in the brief time at my disposal, to do full justice to Prof. Pickering's excellent work, and consequently I must reluctantly pass over many points of interest worthy of attention, and confine my remarks for a few minutes to the general catalogue of results containing all the main details of the investigation. The system of abbreviation, once understood, is

a great convenience, as it increases the space for the insertion of more facts and references. The catalogue, as I have already stated, contains the fullest particulars relating to the photometric observation of 4,260 stars. A mere glance at its crowded columns, extending over 173 pages, is sufficient evidence of the magnitude of the undertaking, the produce of only three years' observation, and less than two years' subsequent computation and research. The catalogue gives the names of the constellations; the designating letters and numbers in various standard catalogues; the approximate right ascensions and declinations for 1880; the eye-estimated magnitudes according to the *Uranometria Nova*, the *Atlas Cœlestis Novus*, the *Durchmusterung*, and the *Uranometria Argentina*; the photometric measures and probable errors; the number of the series; the residuals in tenths of a magnitude, obtained by subtracting the mean photometric magnitude from the separate results of the photometric measures; the corresponding residuals of the separate direct estimated magnitudes; and the results of no less than fourteen series of estimates of antecedent astronomers, commencing with Ptolemy, compared with the mean photometric magnitudes, the residuals being expressed in the same form as for the direct estimations. These former estimates have been reduced to one uniform scale by a method explained by Prof. Pickering.

In April 1879, a circular was issued from the Harvard Observatory, in which was suggested the employment of certain stars very near the North Pole as photometric standards of stellar magnitude. In connection with this proposal, seven stars, sufficiently bright, were observed for this purpose. Four of these—*Polaris*, δ *Ursæ Minoris*, *Cephei* 51, and λ *Ursæ Minoris*—are included in the general catalogue, the photometric magnitudes of the remaining three being 6·5, 8·0, and 8·8 respectively. Omitting *Polaris*, from fourteen to seven measures of each star were obtained with a mean probable error of ·04. The photometric measures of twenty-six stars in the *Pleiades* group have also been made and compared with the eye-estimations of Bessel, Argelander, C. Wolf, Pritchard, and Lindemann. The residuals are no greater than might have been expected, those of Pritchard and Lindemann being very small. These are only a few of many other miscellaneous series of photometric observations undertaken by Prof. Pickering, to which my limited time will not permit me to allude. I may, however, again remark that stars known to have been used as standards of comparison for variable stars, especially those employed by Argelander, Schönfeld, and Oudemans, have been observed with the meridian-photometer as far as practicable. He has also successfully applied the principle of polarisation of light to the photometry of double stars.

It has struck me very forcibly, while examining the columns of residuals in the general catalogue, that the average deviations from the mean are in most cases within reasonable limits; yet

in many instances they are considerable, far exceeding what we might expect in an observation of this kind. Possibly, in a few cases, the wrong object has been observed, though Prof. Pickering remarks that this could not frequently have been done, as there were several checks adopted to assist in the identification of the object. There may be other causes for the large deviations, such as the varying effects of atmospheric absorption produced by mist or unobserved passing clouds, and sometimes from the rapidity with which the observations were made. As a rule, however, the effect of these apparently large discordances, amounting occasionally to a whole magnitude, is probably for the most part eliminated in the mean result.

With regard to the accidental errors contained in the catalogue, Prof. Pickering remarks that ten series of observations of *Polaris*, the photometric magnitude of which he has assumed to be 2·15, were made in order to determine the accordance of successive comparisons made in the same part of the photometric circle. He found the mean discordance of the ten results to be just one-tenth of a magnitude, thus making the corresponding average deviation of the mean of four comparisons ·05. This quantity he assumes to be the average deviation of one set when the comparisons are made at the same part of the circle, or near the same time. Prof. Pickering has also found that the average deviation of one set of four comparisons, at the upper culmination, between *Polaris* and one of the standard circumpolar stars is ·16, and as the mean of the probable errors of the photometric magnitudes determined from all the stars in the catalogue is ·072, and the average number of observations 4·4, the corresponding average deviation is also ·16, thus agreeing with the value obtained from the circumpolar stars alone. Prof. Pickering considers that this deviation of ·16 is due to various causes, the effect of some of which may be separately determined. He has, consequently, deduced an average deviation of ·11, which he attributes to the combination of several causes, such as changes in the instrument or the eye; personal equation between the observers; the uncertainty of the instrumental correction determined from the three observations of *Polaris*; and from the neglect of hundredths of a magnitude in the original computations. He also considers that additional causes may be found in "the variations in the transparency of the atmosphere, actual variations in the light of the stars, undetected errors in identifying the object observed, and mistakes in recording the observations."

Comparing the Harvard results with those of Sir John Herschel's northern and southern sequences, we find the respective differences are ·09 and ·16; with Argelander's magnitudes ·18, with Westphal's ·26, and with Zöllner's ·12. The differences between the Harvard photometric magnitudes of the larger stars in the *Pleiades* and the corresponding values determined by Prof. Pritchard and Lindemann are ·09 and ·14

respectively, and for certain stars compared with variables by Argelander and Schönfeld, ·11 each. Taking 179 stars common to the catalogues of Seidel, Wolff, and the Harvard photometric catalogue, it is found that Harvard differs from Seidel by ·200, and from Wolff by ·120, while Seidel and Wolff differ by ·201. Hence the average deviations of the three catalogues are respectively ·18, ·09, and ·09. These results are in accordance with those found by other methods, and they tend to increase our confidence in the resulting photometric magnitudes of all the separate stars contained in this magnificent contribution to stellar astronomy, with which the name of Prof. Pickering will in future be honourably associated.

It is now time to refer to the corresponding investigation carried on at the University Observatory at Oxford during the last four years, under the able direction of Prof. Pritchard. I believe that I am correct in saying that at the commencement of the observations he was unaware of the methods and intentions of Prof. Pickering, with respect to the system of photometric observations pursued at the Harvard Observatory. Prof. Pritchard's primary object in selecting this branch of research as a fitting one for the new Observatory was the conviction that here an interesting field of inquiry, hitherto to some extent neglected, was open to him. We must, therefore, for our present purpose consider the two investigations as strictly independent and original, and as such they are both recognised by the Council in their award of a joint Medal.

At the meeting of the Society on November 11, 1881, Prof. Pritchard described a simple and practicable method of measuring with considerable accuracy the relative apparent magnitudes of the stars, by means of a new photometer which he had devised, since known as the "wedge-photometer." He, however, claimed no novelty as to the particular implements employed, but only as to the definite methods of applying them and of reducing the results. He had at that time made a photometric comparison of about fifty stars, by which he was assured that far greater precision could be attained in the relative differences of magnitude than by any system of eye-estimation. On May 11, 1883, Prof. Pritchard presented a more elaborate memoir to the Society, entitled, "Photometric Determinations of the relative Brightness of the Brighter Stars North of the Equator" (*Memoirs of the Roy. Astron. Soc.* vol. xlvii.), containing a description of the wedge-photometer, the system of observation, and a statement of the results obtained to the date of publication. The memoir also contains a most interesting historical epitome of all that had been previously accomplished by others in this interesting branch of astronomy, both in the determinations of star magnitudes by photometers of various constructions and also by eye-estimation. The general methods adopted by preceding observers, especially those of Sir William Herschel, Sir John Herschel, and Argelander, are discussed, and the whole

chapter gives a very general notion of the history of the subject. Besides a full explanation of the theory and use of the wedge-photometer, this memoir also includes a photometric determination of the value of the constant of absorption produced by the atmosphere, and notes on the measurement and magnitude of coloured stars, and on the variation of the amount of the extinction of light due to the varying altitude of the star. Although in the Oxford observations the curves graphically representing the variations of brilliancy of the same star at different altitudes were not altogether satisfactory to Prof. Pritchard, he observes that "they did in general represent variations proceeding in accordance with some law, and were fairly consistent until the zenith distance exceeded 60°, but beyond that distance the results were sometimes discordant, and not seldom apparently lawless." So important and essential to his inquiry did Prof. Pritchard consider an accurate knowledge of the value of the absorption constant, that, with his accustomed vigour, he resolved to compare the results of the observations made at Oxford with others determined with the same instrument and observer in some climate steadier and more uniform than that at Oxford. Accordingly, in January and February 1883, we find him, with his assistant, Mr. Jenkins, stationed at the Khedive's Observatory, near Cairo, prosecuting his research with such success that, after a residence of five weeks, no fewer than 3,385 wedge extinctions were made. The absorption constant determined at the two stations, though indicating a real difference of climate, differed less than had been anticipated, the respective values from the Oxford and Cairo extinctions being ·253 and ·187, or ·066 of a magnitude—a quantity about equal to the probable error of an observation with the photometer employed. It may be remarked that Prof. Langley on Mount Etna found the coefficient of absorption to be ·126, Müller at Potsdam ·209, Bouguer in Brittany ·225, and Seidel and Pickering ·250. The corresponding photometric magnitudes determined at Oxford and Cairo are given in the memoir. The measures included in this preliminary synopsis of results are confined to stars brighter than the fifth magnitude of Argelander's scale, and the adopted values are all zenithal magnitudes, the comparison having been made assuming the zenithal magnitude of *Polaris* to be 2·05. The corresponding magnitudes from the catalogues of Ptolemy, Al Sûfi, Argelander, Houzeau, and Gould are inserted for comparison.

This memoir and other shorter communications on the subject have been followed by a more complete work, *Uranometria Nova Oxoniensis*, containing the results of all Prof. Pritchard's photometric observations. Among other kindred works on photometry, this collection of results must take a prominent place, and it will assuredly rank as a standard treatise on the subject, as a reliable exposition of the relative photometric magnitudes of the principal stars visible to ordinary and unaided

eyes from the North Pole to about ten degrees south of the Equator. For the sake of accuracy, I extract from the introduction to this volume Prof. Pritchard's explanation of the construction of the wedge-photometer, with which all his observations have been made. "The wedge-photometer, as employed at Oxford, is a wedge of very nearly neutral tinted glass, $6\frac{1}{2}$ inches long, 1 inch broad, and ·145 inch thick, tapering off to ·02 inch. Cemented to it is a similar wedge of white glass, placed the reverse way; the whole forming a rectangular prism. This glass prism, or *wedge*, is inclosed in a brass cellular rim with bevelled edges, one of which is divided into tenths of inches, the divisions being distinct and white for visibility at night. It slides in a groove on the brass cap of the eyepiece of any telescope, close to the achromatic eye-lens, and is thus placed between the eye of the observer and the telescope. In the focus of the eye-lens is a diaphragm, pierced with a number of small holes, which vary from the hundredth of an inch to a quarter of an inch in diameter, and in which small circular hole the telescope image of a star is carefully placed, and there viewed through the wedge. Further, the eye of the observer is directed along the axis of the lens and of the telescope by means of an external eye-hole, placed close to the wedge, and varying from one-twelfth of an inch to a quarter of an inch. This direction of vision is important. A fiducial mark is drawn on the brass cap of the eyepiece, so that the position of the wedge can be distinctly marked and recorded when the image of the star is just extinguished by the wedge. Usually the position of the wedge, when the light of the star is just extinguished, is observed five times, and the mean of all the five readings is called the *wedge reading*. The extinction of a second star is then observed in a similar manner, and the difference between the two wedge readings is called the *wedge interval*."

It has been customary at Oxford to select about ten stars for one night's work, at nearly the same altitude as the comparison star *Polaris*, so that any correction to the measures for absorption may be avoided. Two telescopes were employed, one of four, the other of three inches aperture, to which photometers were respectively attached. These telescopes being in separate domes, the two observers were each instructed to measure the specified stars independently, taking the precaution to observe the extinction of *Polaris* at the beginning, the middle, and the end of the series. The extinctions of the comparison star were observed five times with the full aperture of the two telescopes, and five times after reducing the aperture to one-half by placing a cap on each object-glass. Thus a check on the first set of five measures was established by means of virtually a new instrument. Then four independent sets of five extinctions were made of each star to be measured, making altogether twenty extinctions. It will thus be perceived that the observations were made in an orderly and systematic manner, and with much simplicity. This

appears to me one of the advantages to be attained by the use of the wedge-photometer.

Prof. Pritchard has ascertained from a special comparison of the means of five extinctions of about twenty stars, made by Mr. W. E. Plummer and Mr. Jenkins, each observing with different apertures the same stars as nearly as possible in point of time, and with the same wedge and telescope, that there is practically no sensible difference of personal equation between the two observers, and that therefore they might safely interchange the instruments without introducing any systematic error in the results.

The 2,784 stars selected for observation are those contained in the *Uranometria Nova* from the North Pole to 10° south of the Equator. The limit of magnitude is therefore Argelander's sixth. In the catalogue the stars are arranged alphabetically in the order of constellations, the separate columns giving the approximate R.A. and N.P.D. for 1890, the adopted zenithal magnitude assuming that of *Polaris* to be 2·05, the average deviation in magnitude, the date of observation, and the corresponding magnitude in the *Uranometria Nova*. Copious notes are given, in which the concluded results for stars observed both at Oxford and Cairo are inserted. We have in this catalogue the relative magnitudes of most of the principal stars visible in the northern hemisphere determined with great precision from upwards of seventy thousand separate extinctions. When we remember that the University Observatory was established under many difficulties, that the observing staff consists of only two assistants, and that during six months of the year much time is given to lecture work and practical instruction to the undergraduates at night, we have strong grounds for giving all the credit that is due to those by whose energy and zeal so much good and standard work has been accomplished since the foundation of this Observatory in 1875.

It is not my desire or intention to make any critical comparison of the results obtained by the wedge-photometer with those derived from other sources. This will probably be done by others at the proper time, and in a more formal manner. But the question naturally arises, are the results obtained by the wedge-photometer to be accepted as fairly accurate representations of the relative stellar magnitudes? Prof. Pritchard considers that they are, as a whole, sensibly accurate to the tenth of a magnitude, and if the probable error be any indication of accuracy, I think he has reasonable grounds for his belief. We have had lately several important discussions at the meetings of the Society on the capabilities of the wedge-photometer, besides other criticisms. Some of these are valuable, especially those of Dr. Wilsing in the *Astronomische Nachrichten*, No. 2,680, but at the same time I believe that the explanations given by Prof. Pritchard in answer to these criticisms have practically smoothed down many of the difficulties pointed out, thus minimising the

effect of some of the systematic errors to which this form of photometer may be liable. Most probably the results derived from every kind of photometer are affected more or less with systematic discordances. I believe there can be no doubt upon this point. But if the deviations from the mean result afford any evidence of the steadiness of observing, it is certainly shown to great advantage in the Oxford observations, though it has been asserted, and not without reason, that the small differences of deviation from the mean is a sign of the want of sensitiveness in the instrument. May we not rather attribute this general agreement partly to the comparatively simple character of the observation, and to the care and attention of the observers? I have been very much impressed on this point by the apparent uniformity exhibited in the tables communicated by Prof. Pritchard to the Society in November last (*Monthly Notices*, vol. xlvi. p. 9), consisting of several nights' repetition of the determinations of the magnitude of sixteen selected stars. These observations were made under different circumstances as regards the condition of the air and the observer. Only in one isolated instance does the difference between the greatest and least daily results exceed four-tenths of a magnitude, while the average deviation from the mean of each of the sixteen stars varies only from ·03 to ·09, or equal to an average deviation of ·06. Referring to the smallness of the discordances, Prof. Pritchard says: "The final results, so far as my powers of scrutiny extend, exhibit no symptoms of systematic error. The average deviation from the mean for all these repeated observations on so many nights still remains approximately the same as for stars measured in the normal manner on a single fair night, viz. about ·06 magnitude; and this, I think, represents in reality the utmost average delicacy attainable with the wedge-photometer, and I claim for it an accuracy at least as great as has been yet attained by any other instrument."

Perhaps it may be considered, and I think very properly so, that one conceivable source of error in the measurement of such minute variations of light might arise from the natural fatigue of the eye during a long series of observations. In order to ascertain whether any error of this kind exists in the Oxford photometric measures, Prof. Pritchard made a special examination of a large number of extinctions of *Polaris* made on separate nights at the beginning, the middle, and the end of each series, from which he appears to be satisfied that there are no real grounds for supposing that any sensible variation in the method of observing, due to fatigue of the eye, takes place during the three hours occupied in making the observations on any one night. From my own personal experience of the ordinary fatigues of a long night's observation with the Greenwich transit-circle, occasionally extending in the winter months over a watch of nine or ten hours, I have invariably found that though at the end of the observations the body may be very

wearied, the eye has usually retained its full sensitiveness, and able to distinguish the faintest objects visible in the telescope equally as well as in the earlier part of the evening. I attribute this apparent retention of acuteness of vision after a long and fatiguing night's work, chiefly to the relief obtained by an occasional rest from observing during the watch, and to the variable work which the eye is called upon to perform during the intervals of actual observation at the telescope. Prof. Pritchard has evidently a similar experience with regard to the Oxford observers, as he finds that any undue strain on the eye is probably compensated by the "relief afforded by continual breaks in the work of actual observation, connected with the shifting of the domes, with the identification of the stars, and with the recording the results." The circumstances of the two cases are not, however, strictly analogous.

It may be a matter of interest to some if I refer to the general agreement existing among the deduced magnitudes of a large proportion of the stars north of the equator common to the Harvard and Oxford catalogues. From a comparison made recently, it is found that the accordances within one-tenth of a magnitude are 31 per cent., within one quarter of a magnitude 71 per cent., and within one-third of a magnitude 95 per cent., leaving only 5 per cent. of discordances exceeding one-third of a magnitude, many of which may be accounted for on reference to the notes. Viewed in this light, and considering that the magnitudes are determined by photometers constructed on totally different principles, we must admit that this general and substantial agreement between the results of the two independent researches is very remarkable, and indicative of a great step having been accomplished towards an accurate knowledge of the relative lustre of the stars.

And now, gentlemen, I have laid before you a short summary of the reasons by which your Council have been guided in the award of a joint Medal for the subject of stellar photometry. In thus recognising the labours of Profs. Pritchard and Pickering, they are glad to acknowledge, at the earliest opportunity, the systematic zeal and devotion displayed by each in the prosecution of their important researches, carried on with an energy which claims our admiration. In Prof. Pritchard we observe an astronomer whose opportunities for stated Observatory work only commenced at a time of life when most of us naturally feel a desire to be relieved from all active research, establishing under difficulties a first-class Observatory, which has already attained a reputation for sound original work, of which many older establishments might well be proud—a reputation that, doubtless, will be retained at least so long as the University Observatory remains under the personal control of our esteemed colleague. We must all congratulate him on the complete success of his labours, in the energetic prosecution of which he has shown himself to be a worthy successor of the long roll of distinguished

Savilian Professors who have preceded him, many of whom are known as honoured and illustrious astronomers, whose investigations form a large portion of the past history of our science. The continuous devotion of Prof. Pickering to astronomical research has also gained for him universal esteem and regard among his associates in astronomy on both sides of the Atlantic, as one of our most original and active inquirers, not only in this branch of the science, the consideration of which has occupied our attention to-day, but also in other important fields of stellar research. By the award of the Medal he is only receiving a due acknowledgment of his valuable services, and a token of the desire of the Council to express their full appreciation of the scientific value of the numerous contributions he has made to astronomy.

The President, on delivering the Medal to Prof. Pritchard and the Foreign Secretary, addressed them respectively in the following terms :—

PROFESSOR PRITCHARD,—

I have very great pleasure in presenting this Medal, which the Council have awarded to you conjointly with Prof. Pickering. I hope you will accept it as an acknowledgment on their part of the excellent work you have accomplished during your superintendence of the University Observatory at Oxford. I assure you that the important contribution you have made to astronomy on the relative magnitudes of the stars is highly appreciated by the Fellows, and I trust that you may still be spared many years to continue your valuable researches.

DR. HUGGINS,—

In forwarding this Medal to Prof. Pickering, I would request you to inform him that the Council entertain the highest opinion on the merits of the important research on which he has been engaged, and for which they have had much pleasure in awarding to him this Medal conjointly with Prof. Pritchard. I trust that what he has so successfully accomplished is only the prelude of further researches, and thus add still more to the great astronomical reputation he has already achieved.